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Koll et al.

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(54) **HYBRID HUMAN AND COMPUTER-ASSISTED CODING WORKFLOW**

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G06Q 10/10 (2012.01)

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CPC ***G16H 10/60*** (2018.01); ***G06Q 10/10*** (2013.01)

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CPC G06F 19/328; G16H 10/60
See application file for complete search history.

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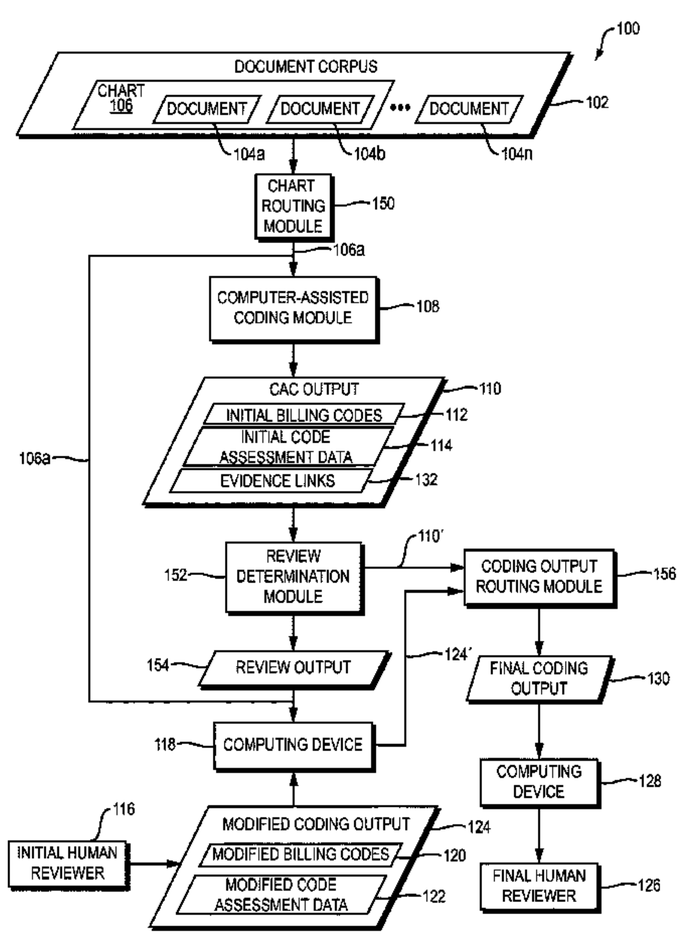
(57) **ABSTRACT**

A computer system increases the efficiency with which billing codes may be generated based on a chart, such as a medical chart. The computer system provides the chart to a computer-assisted coding (CAC) module, which produces an initial set of billing codes and an initial assessment of the accuracy and/or completeness of the codes. The computer system decides whether to send the initial set of billing codes to an initial human reviewer. If the computer system sends the initial set of billing codes to the initial human reviewer, then the initial human reviewer reviews the chart and the output of the CAC module, and attempts to fix errors in the CAC output. The system provides the chart and the current (initial or modified) codes to a final human reviewer, who may be more highly skilled than the initial human reviewer, for final verification and modification.

12 Claims, 2 Drawing Sheets



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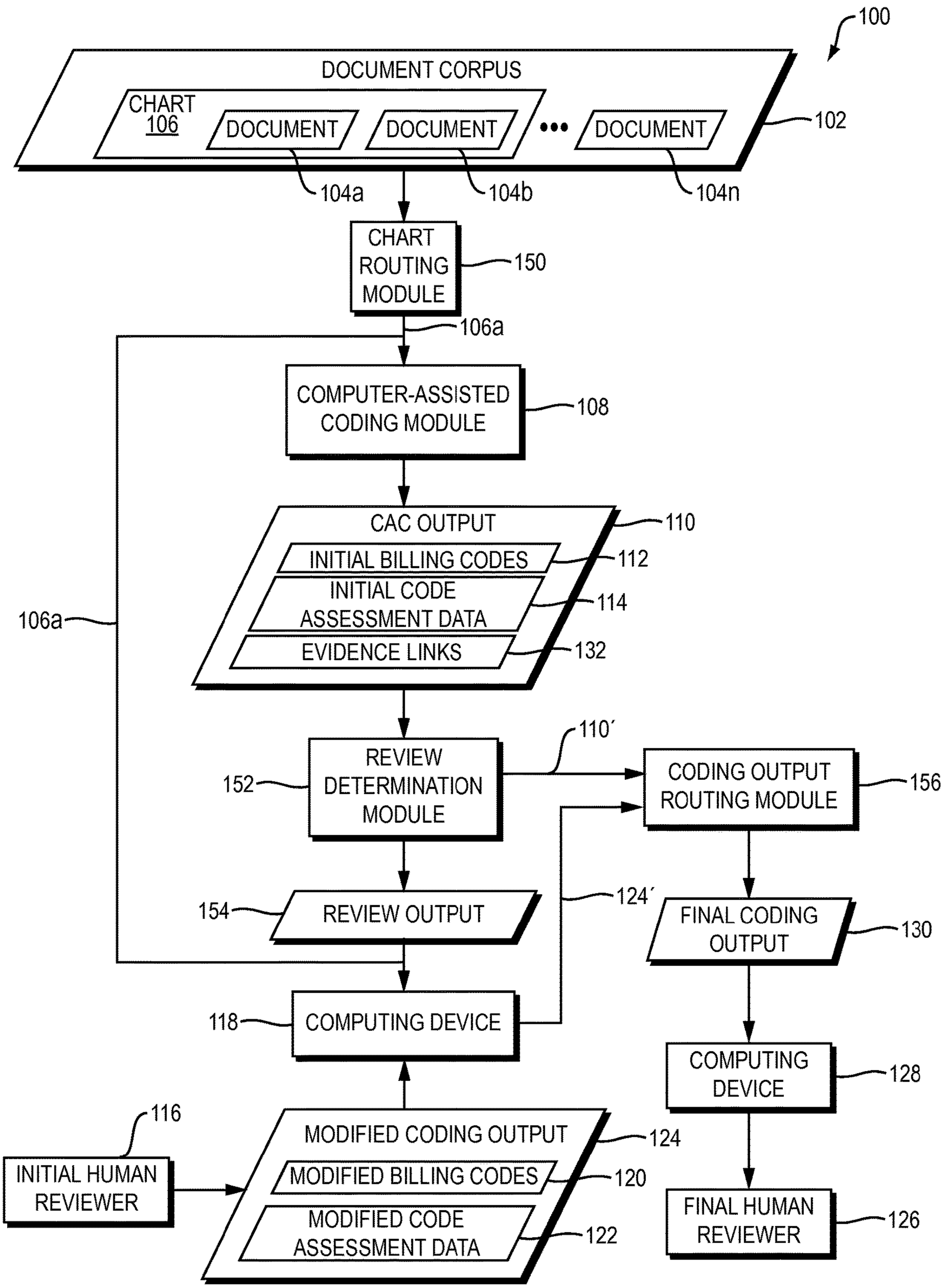
100
DOCUMENT CORPUS
CHART 106
DOCUMENT
DOCUMENT
DOCUMENT
102
104a
104b
104n
CHART ROUTING MODULE
150
106a
COMPUTER-ASSISTED CODING MODULE
108
CAC OUTPUT
110
INITIAL BILLING CODES
112
INITIAL CODE ASSESSMENT DATA
114
EVIDENCE LINKS
132
106a
REVIEW DETERMINATION MODULE
152
110′
CODING OUTPUT ROUTING MODULE
156
REVIEW OUTPUT
154
124′
FINAL CODING OUTPUT
130
COMPUTING DEVICE
118
COMPUTING DEVICE
128
116
INITIAL HUMAN REVIEWER
MODIFIED CODING OUTPUT
124
MODIFIED BILLING CODES
120
MODIFIED CODE ASSESSMENT DATA
122
FINAL HUMAN REVIEWER
126

FIG. 1

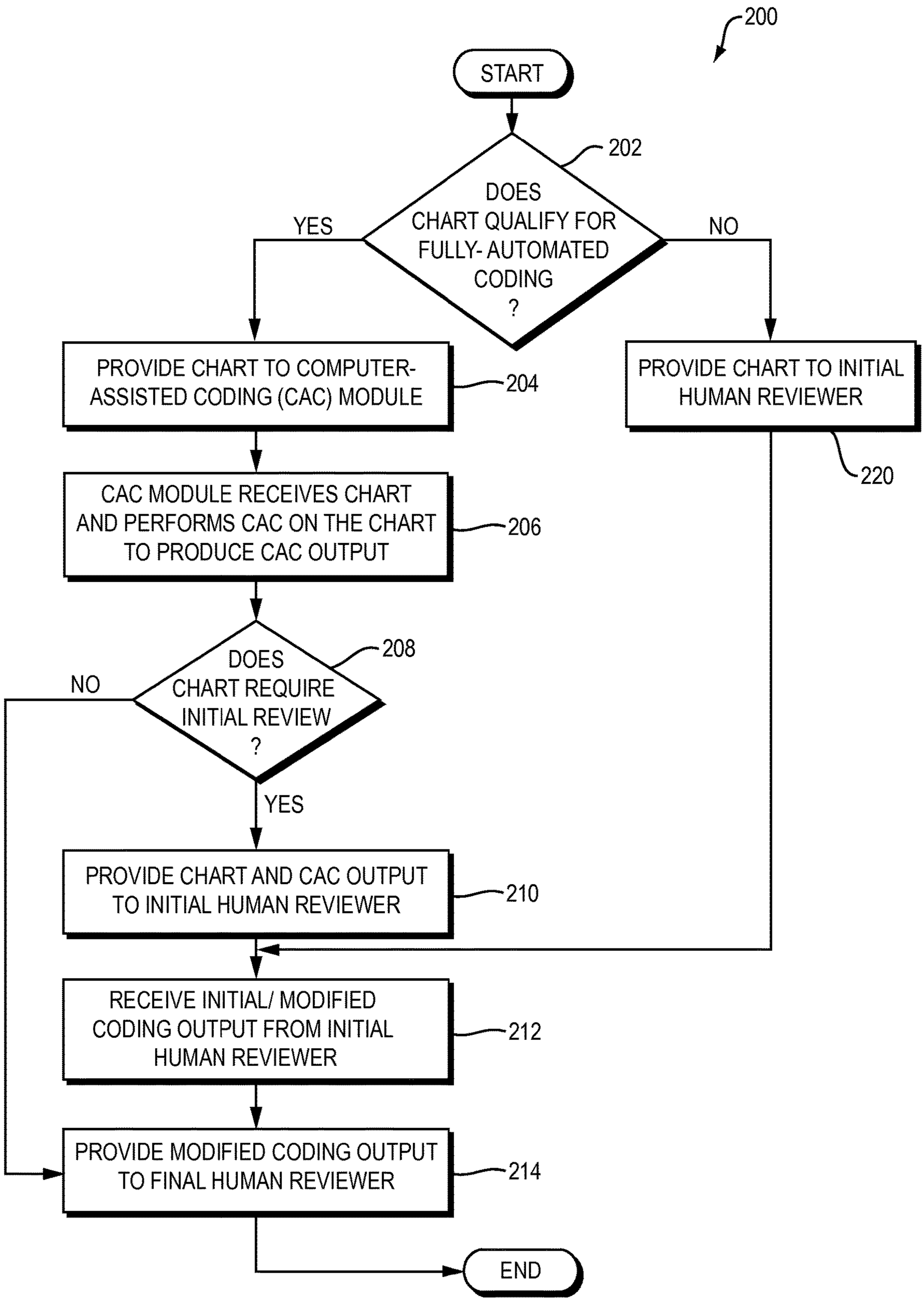
200
START
202
DOES CHART QUALIFY FOR FULLY- AUTOMATED CODING ?
YES
NO
PROVIDE CHART TO COMPUTER-ASSISTED CODING (CAC) MODULE
204
PROVIDE CHART TO INITIAL HUMAN REVIEWER
220
CAC MODULE RECEIVES CHART AND PERFORMS CAC ON THE CHART TO PRODUCE CAC OUTPUT
206
208
DOES CHART REQUIRE INITIAL REVIEW ?
NO
YES
PROVIDE CHART AND CAC OUTPUT TO INITIAL HUMAN REVIEWER
210
RECEIVE INITIAL/ MODIFIED CODING OUTPUT FROM INITIAL HUMAN REVIEWER
212
PROVIDE MODIFIED CODING OUTPUT TO FINAL HUMAN REVIEWER
214
END

FIG. 2

HYBRID HUMAN AND COMPUTER-ASSISTED CODING WORKFLOW

BACKGROUND

After physicians and other healthcare professionals (referred to herein generally as "healthcare providers") provide healthcare services to patients, bills for such services must be generated. The process of generating such bills based on the set of clinical reports associated with a patient encounter (referred to as a "chart") can be a tedious, time-consuming, risky, and error-prone process for a variety of reasons, such as:

- Laws, regulations, and institutional policies prescribe that bills satisfy various rules, such as rules requiring that each item in a bill be justified by adequate supporting evidence. Such rules can be difficult to identify and interpret, and the required evidence can be difficult to find and evaluate.
- Bills must be encoded using billing codes specified by technical billing code standards such as ICD-9, ICD-10, and CPT. Such standards can be difficult to understand and apply in particular situations in light of the services provided and the available evidence. Furthermore, as older standards (such as ICD-9) are replaced with newer, more complex, standards (such as ICD-10), the difficulty of understanding the applicable standards is increasing.
- Bills often must be generated quickly due to time and budget constraints.
- The error rate in bills, including both false positives and false negatives, must be kept to a minimum. False positives (including items in bills that should not be included, such as because they are not justified by available evidence) may violate applicable laws, regulations, and/or institutional policies. False negatives (failing to include items in bills that should be included) lead to lost revenue for the healthcare provider.
- Billing codes are typically generated by specialized "billing coders," who must be trained to select the appropriate codes based on the documentation provided by the healthcare providers. Training a billing coder can be time-consuming and expensive, and even expert billing coders can make mistakes.

These problems are likely to be exacerbated by the transition to the ICD-10 billing code standard. Expert billing coders, who are fluent in ICD-10, are in short supply and are unlikely to meet the demand for such billing coders.

In order to address this shortfall in supply of expert billing coders, many healthcare providers have either been outsourcing their coding process to service companies or attempting to automate the coding process using Computer Assisted Coding (CAC) technology.

Both outsourcing and automation have associated drawbacks. For example, because the ability to perform billing coding accurately and completely directly impacts the cash flow and overall profitability of healthcare organizations, such organizations are reluctant to rely on an outsourced workforce. Another drawback of outsourced billing coding is that the ultimate responsibility, and legal liability, for the accuracy of billing coding lies with the healthcare organization, few (if any) outsourced billing coding providers are willing to indemnify a sizable healthcare organization against liability incurred as the result of billing coding errors. As a result, even healthcare organizations that are willing to outsource may not be able to outsource all of their billing coding needs to billing coding providers who can satisfy exacting quality and legal requirements.

CAC solutions have their own problems. CAC solutions apply Natural Language Processing (NLP) technology to compute the most likely set of billing codes from a set of clinical reports before a human coder reviews the chart. Some CAC solutions can, in addition, create confidence scores that estimate the likelihood that any given code, or the complete coding of a chart, is correct. Some CAC solutions provide the option of bypassing the human coder completely, for at least a subset of charts, if the chart-level confidence score is sufficiently high. The state of the art of such fully-automated coding, however, is not sufficiently accurate to be relied upon in practice for anything but the most simple charts. More complex charts, which are the norm in practice, cannot be accurately coded using fully-automated coding. As a result, in practice it is necessary, in most cases, for a human coder to review the automatically-generated codes for accuracy and to revise such codes as necessary.

The promise of CAC solutions, even when the codes that they generate must be reviewed by a human coder, is to provide an increase in efficiency in comparison with a system that relies solely on human coders, by providing the initial set of codes for review quickly and accurately enough that the combination of generating codes automatically followed by human review and correction of those codes is more efficient and inexpensive than purely human code generation. In practice, however, CAC systems do not always increase productivity as much as is theoretically possible. Furthermore, deploying CAC systems requires a lengthy and labor-intensive tuning process to adapt the CAC technology to the idiosyncrasies of a healthcare provider. The result is that productivity during the tuning process can be impacted negatively, and the resulting overall productivity may be lower than if no CAC system were used at all.

What is needed, therefore, are techniques for overcoming the problems of conventional CAC systems, and for otherwise improving the efficiency of generating billing codes.

SUMMARY

A computer system increases the efficiency with which billing codes may be generated based on a chart, such as a medical chart. The computer system provides the chart to a computer-assisted coding (CAC) module, which produces an initial set of billing codes and an initial assessment of the accuracy and/or completeness of the codes. The computer system decides whether to send the initial set of billing codes to an initial human reviewer. If the computer system sends the initial set of billing codes to the initial human reviewer, then the initial human reviewer reviews the chart and the output of the CAC module, and attempts to fix errors in the CAC output. The system provides the chart and the current (initial or modified) codes to a final human reviewer, who may be more highly skilled than the initial human reviewer, for final verification and modification.

Other features and advantages of various aspects and embodiments of the present invention will become apparent from the following description and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a dataflow diagram of a system for generating billing codes according to one embodiment of the present invention; and

FIG. **2** is a flowchart of a method performed by the system of FIG. **1** according to one embodiment of the present invention.

DETAILED DESCRIPTION

Embodiments of the present invention include computer systems which may be used to improve the efficiency with which billing codes may be generated. Referring to FIG. **1**, a dataflow diagram is shown of a system **100** for generating billing codes according to one embodiment of the present invention. Referring to FIG. **2**, a flowchart is shown of a method **200** performed by the system **100** of FIG. **1** according to one embodiment of the present invention.

The system **100** includes a document corpus **102**, which includes a plurality of documents **104***a-n*, where n may be any number. The document corpus **102** is merely one example of a "data set" as that term is used herein. The term "document" is used generally herein to include any type of data record, such as a freeform text document (e.g., a plain text document or a document created using a word processing application), a structured document (such as an XML document), a scanned document (e.g., a scan of handwritten progress notes), or a data record in a database. A document may, for example, be an Electronic Medical Record (EMR) or Electronic Health Record (EHR). Structured documents in the document corpus **102** may, for example, have been created using techniques disclosed in U.S. Pat. No. 7,584,103 B2, issued on Sep. 1, 2009, entitled, "Automated Extraction of Semantic Content and Generation of a Structured Document from Speech."

The document corpus **102** may include documents of different types, such as text documents and EHRs. Although FIG. **1** shows just one document corpus **102**, the document corpus **102** may include multiple data sets, such as multiple databases, files stored in multiple file systems, multiple EMR/EHR databases, or any combination thereof. As these examples illustrate, the document corpus **102** may include documents stored on a plurality of storage media (e.g., hard drives) and/or maintained by multiple computer systems.

For ease of explanation, certain embodiments will be disclosed herein in connection with documents which take the form of clinical reports describing patient encounters. Examples of clinical reports include admission orders, discharge orders, and prescriptions. A plurality of clinical reports relating to a particular patient encounter is referred to herein as a "chart." Often, the process of generating a set of billing codes involves generating a set of billing codes based on the clinical reports in a particular chart. The resulting billing codes may be represented in any manner, such as according to billing code standards such as any one or more of HL7 CDA v2 XML standard (ANSI-approved since May 2005), SNOMED CT, LOINC, CPT, ICD-9 and ICD-10, and UMLS.

Assume, solely for purposes of example, that the system **100** includes a chart **106**, which includes documents **104***a-b* from the document corpus. As mentioned above, a chart may, more generally, including one or more documents relating to a particular patient encounter. Although the chart **106** is shown as being contained within the document corpus **102** in FIG. **1**, the chart **106** need not exist as a data structure within the document corpus **102**. Instead, for example, another component of the system **100** may store data (e.g., in a separate database) indicating that the chart **106** includes the documents **104***a* and **104***b*.

Now assume that the chart **106** is ready to be used to generate a set of billing codes based on the chart **106**. Further assume that the system **100** includes a computer-assisted coding (CAC) module **108**. The CAC module **108** may include any number and type of computer hardware, computer software, networking equipment, and interconnections sufficient to enable the CAC module **108** to perform computer-assisted coding. The CAC module **108** is configured to perform, or to attempt to perform, computer-assisted coding without the involvement of a human, except that a human may provide the chart **106** to the CAC module **108** and interpret the output of the CAC module **108**.

The system **100** may include a chart routing module **150**, which may receive some or all of the chart **106** as input, and which may determine whether the chart **106** qualifies for fully-automated processing by the CAC module **108** (FIG. **2**, operation **202**). The chart routing module **150** may make this determination in any of a variety of ways. For example, the chart routing module **150** may determine whether the chart **106** includes any scanned handwritten notes and determine that the chart **106** does not qualify for fully-automated processing by the CAC module **108** in response to determining that the chart **106** includes at least one scanned handwritten note. As another example, the chart routing module **150** may determine whether the chart **106** has a high confidence of being coded accurately by the CAC module **108**. The chart routing module **150** may make this determination by, for example, determining whether the chart **106** describes a complex medical procedure, and concluding that the chart **106** has a high confidence of being coded accurately by the CAC module **108** only if the chart **106** does not describe a complex medical procedure. The system **100** may determine whether a medical procedure is "complex" in any of a variety of ways, such as by determining whether the procedure lasted more than a predetermined amount of time (e.g., 6 hours), or by determining whether the patient who is the subject of the procedure stayed in the hospital for longer than some predetermined amount of time (e.g., 3 days). As yet another example, the chart routing module **150** may conclude that a medical procedure is "complex" and requires non-automated coding if the lab values of the patient who was the subject of the medical procedure has non-normal lab values. Regardless of how the chart routing module **150** determines that the chart **106** has a high confidence of being coded accurately by the CAC module **108**, the chart routing module **150** may determine that the chart **106** qualifies for fully-automated processing by the CAC module **108** in response to determining that the chart **106** has a high confidence of being coded accurately by the CAC module **108**.

If the chart routing module **150** determines that the chart **106** qualifies for fully-automated processing, the chart routing module **150** may provide output **106***a* representing the chart **106** to the CAC module **108** for processing (FIG. **2**, operation **204**). For ease of explanation, the following description will refer to the CAC module **108** as operating on the chart **106** instead of the chart output **106***a*. The CAC module **108** may receive the chart **106** and perform computer-assisted coding on the chart **106** to produce CAC output **110** (FIG. **2**, operation **206**). The CAC output **110** may include one or more of the following:

- A set **112** of initial billing codes, including one or more billing codes generated by the CAC module **108** based on the chart **106**.
- Initial code assessment data **114**, representing an overall assessment of the completeness and/or correctness of the initial billing codes **112**.
- Links **132** to evidence that is relevant to the set **112** of initial billing codes. Such evidence may include, for

example, one or both of the following: (1) evidence that was found by the CAC module **108** but that the CAC module did not rely upon to generate the set **112** of initial billing codes; and (2) evidence that was found by the CAC module **108** and that the CAC module did rely upon to generate the set **112** of initial billing codes.

The initial code assessment data **114** may include any of a variety of data. For example the initial code assessment data **114** may include any one or more of the following:

- data representing an overall assessment of the completeness of the initial billing codes **112**;
- data representing a completeness confidence score indicating a confidence that the initial billing codes **112** are complete, i.e., that the initial billing codes **112** include all billing codes that can be generated based on the chart **106**;
- data representing a correctness confidence score indicating an overall confidence that the initial billing codes **112** are correct, i.e., that the initial billing codes **112** accurately encode billing information for the healthcare services represented by the chart **106**; and
- data representing an overall classification of the initial billing codes **112**, such as "likely completely correct," "requires review," or "known deficiencies."

The initial code assessment data **114** may indicate that the initial billing codes **112** are likely completely correct based on, for example, a function of the completeness confidence score and/or the correctness confidence score. For example, if the correctness confidence score exceeds a first predetermined threshold (e.g., 95%) and the completeness confidence score exceeds a second predetermined threshold (e.g., 90%), then the system **100** may conclude that the initial billing codes **112** are likely completely correct.

The initial code assessment data **114** may indicate that the initial billing codes **112** contain a known deficiency if, for example, the chart **106** is missing a required report, such as a "Discharge Summary" report.

The system **100** may also include a review determination module **152**, which may receive some or all of the CAC output **110** as input, and which may determine whether the initial code assessment data **114** indicates that the chart **106** has been classified as requiring review (FIG. **2**, operation **208**). If the review determination module **152** determines that the chart **106** has been classified as requiring review, then the review determination module **152** may provide output **154** containing or otherwise representing the chart **106** and the CAC output **110** (or a portion thereof) to an initial human reviewer **116**, such as by transmitting the review output **154** (e.g., the chart **106** and CAC output **110**) over a network to a computing device **118** used by or otherwise associated with the initial human reviewer **116** (FIG. **2**, operation **210**). The initial human reviewer **116** may, for example, be a junior or relatively inexperienced and/or unskilled reviewer (e.g., billing coder). If the review determination module **152** determines that the chart **106** has not been classified as requiring review, then the review determination module **152** may produce output **110'** representing the CAC output **110**, and provide the output to a coding output routing module **156**, which is described in more detail below.

Although not shown in FIG. **2** or **3**, the review determination module **152** may determine whether providing the CAC output **110** to the initial human reviewer **116** is likely to add value to the CAC output **110**, and only provide the CAC output **110** to the initial human reviewer **116** in response to determining that the initial human reviewer **116** is likely to add value to the CAC output **110**. For example, the review determination module **152** may determine, in operation **208**, whether the chart **106** requires initial human review, and also determine whether review of the CAC output **110** by the initial human reviewer **116** is likely to add value to the CAC output **110**, and then only provide the CAC output **110** to the initial human reviewer **116** if the review determination module **152** determined that the chart **106** requires initial human review and that the initial human reviewer **116** is likely to add value to the CAC output **110**.

The review determination module **152** may determine whether the initial human reviewer **116** is likely to add value to the CAC output **110** in any of a variety of ways. For example, the review determination module **152** may make this determination in any of the ways disclosed herein by which the chart routing module **150** may determine whether the chart **106** describes a complex medical procedure. The review determination module **152** may, for example, use any such technique to determine whether the CAC output **110** and/or the chart **106** describes a complex medical procedure, and not provide the CAC output **110** to the initial human reviewer **116** in response to determining that the CAC output **110** and/or the chart **106** describes a complex medical procedure.

As another example, the review determination module **152** may determine whether the initial human reviewer **116** is likely to add value to the CAC output **110** by determining whether the initial human reviewer **116** is sufficiently skilled to add value to the CAC output **110**. The review determination module **152** may, for example, determine whether the initial human reviewer **116** is sufficiently skilled to add value to the CAC output **110**, and not provide the CAC output **110** to the initial human reviewer **116** in response to determining that the initial human reviewer **116** is not sufficiently skilled to add value to the CAC output **110**. The review determination module **152** may determine whether the initial human reviewer **116** is sufficiently skilled to add value to the CAC output **110** in any of a variety of ways. For example, the review determination module **152** may determine whether a skill value associated with the initial human reviewer **116** satisfies a skill criterion (e.g., exceeds a maximum predetermined value), and not provide the CAC output **110** to the initial human reviewer **116** in response to determining that the skill value does not satisfy the skill criterion.

If the chart routing module **150** previously determined (in operation **202** of FIG. **2**) that the chart **106** did not qualify for fully-automated coding, then the chart routing module **150** may provide the chart **106** to the initial human reviewer **116** (FIG. **2**, operation **220**). In other words, if the CAC module **108** processes the chart **106** to produce the CAC output **110**, then the CAC output **110** may be provided to the initial human reviewer **116**, whereas if the CAC module **108** does not process the chart **106**, then the chart **106** may be provided to the initial human reviewer **116**. If the chart **106** is provided to the initial human reviewer **116**, then the initial human reviewer **116** may manually code the chart **106** to produce modified coding output **124**, without the use of the CAC module **108**. The following discussion, however, assumes that the automatically-generated CAC output **110** is provided to the initial human reviewer **116**.

Any of the operations described herein as being performed in connection with the output **110'** of the CAC module **108** may alternatively be performed on the output **124'** of the initial human reviewer **116** (e.g., if the chart output **106***a* is provided to the initial human reviewer **116** but not to the CAC module **108**). Furthermore, any operations described herein as being performed on the output **110'** of the CAC module **108** may be performed on both the

output **110'** of the CAC module **108** and the output **124'** of the initial human reviewer **116**.

The initial human reviewer **116** may review the initial billing codes **112** for completeness and/or correctness. Before doing so, however, the initial human reviewer **116** may determine whether to review the initial billing codes **112**. For example, the initial human reviewer **116** may determine whether the chart **106** can be coded (i.e., whether the initial billing codes **112** can be modified) with high confidence. If the initial human reviewer **116** determines that the chart **106** cannot be coded with high confidence, then the initial human reviewer **116** may skip the following steps involving reviewing the initial billing codes **112** for completeness and/or correctness.

As another example, the initial human reviewer **116** may determine whether the total amount of reimbursement represented by the chart **106** and/or the initial billing codes **112** exceeds some predetermined threshold amount, such as an average reimbursement amount or an approved reimbursement amount. If the initial human reviewer **116** determines that the total amount of reimbursement exceeds the predetermined threshold amount, then the initial human reviewer **116** may skip the following steps involving reviewing the initial billing codes **112** for completeness and/or correctness.

The initial human reviewer **116** may, based on any combination of the chart **106**, the initial billing codes **112**, and the initial code assessment **114**, modify the initial billing codes **112** in an attempt to increase their completeness and improve their correctness, thereby producing a set of modified billing codes **120**. The initial human reviewer **116** may also modify the initial code assessment **114** to indicate, for example, the initial human reviewer **116**'s assessment of the completeness and/or correctness of the modified billing codes **120**, thereby producing a modified code assessment **122**. Both the modified billing codes **120** and the modified code assessment **122** may be part of modified coding output **124** produced by the initial human reviewer **116**.

The initial human reviewer **116** may also perform additional tasks based on the chart **106** and/or the CAC output **110**. One purpose of these additional tasks may be to assist a subsequent human reviewer in reviewing the chart **106** and/or the modified coding output **124**. For example, the initial human reviewer **116** may perform any one or more of the following additional tasks based on the chart **106** and/or the CAC output **110**:

- sort clinical documents in the chart **106** in order of decreasing relevance;
- mark individual documents within the chart **106** as relevant and/or irrelevant; and
- mark the text positions of relevant portions of documents within the chart **106**, and/or extract such relevant portions from the documents.

Data representing the results of any such additional actions may be stored within the modified coding output **124**. For example, the modified coding output **124** may include data representing the initial human reviewer **116**'s selected sort order of documents within the chart **106**. The initial human reviewer **116**, via the computing device **118**, may provide output **124'** containing or otherwise representing the modified coding output **124** back to the system **100** (FIG. **2**, operation **212**).

The system **100** may include a coding output routing module **156**. The coding output routing module **156** may provide a final human reviewer **126** with final coding output **130**, which may include and/or be derived from either:

- the CAC output **110** or **110'**, if the CAC output **110** was not provided to or modified by the initial human reviewer **116**; or
- the modified coding output **124** or **124'**, if the CAC output **110** was modified by the initial human reviewer **116** to produce the modified coding output **124**.

The final coding output **130** may also include the chart **106** and/or data derived from the chart **106**. The coding output routing module **156** may, for example, provide the chart **106** and the final coding output **130** to the final human reviewer **126** by transmitting the chart **106** and the final coding output **130** over a network to a computing device **128** used by or otherwise associated with the final human reviewer **126** (FIG. **2**, operation **214**). The final human reviewer **126** may, for example, be a senior or relatively experienced or expert reviewer (e.g., billing coder), and may be a different person than the initial human reviewer **116**. The final coding output **130** may, for example, be:

- the CAC output **110**, if the CAC output **110** was not sent to or modified by the initial human reviewer **116**, in which case the final coding output **130** may include both the initial billing codes **112** and the initial code assessment **114**; or
- the modified coding output **124**, if the initial human reviewer **116** modified the CAC output **110** to produce the modified coding output **124**, in which case the final coding output may include the modified billing codes **120** and the modified code assessment **122**.

The final human reviewer **126** may review the chart **106** and the final coding output **130**, and analyze them for any of a variety of purposes. For example, the final human reviewer **126** may choose to perform any one or more of the following, in any combination:

- allow codes classified as "likely completely correct" to be submitted for billing without further review;
- allow codes classified as "likely completely correct" to be submitted for billing without further review, except for a randomly selected sample of codes, which may be processed by a quality assurance procedure to verify their accuracy;
- if the chart **106** (or specific codes therein) has been classified as "requiring further review," then use the modified coding output **124** to code the chart **106** (or the specific codes therein); and
- if the chart **106** (or specific codes therein) has been classified as "known deficiencies," then route the chart (or specified codes therein) to a specialized workflow.

Although FIG. **1** only shows a single chart **106**, the system **100** of FIG. **1** may repeat the method **200** of FIG. **2** for any number of charts.

Embodiments of the present invention have a variety of advantages, such as the following. In general, embodiments of the present invention address shortcomings of CAC technology, by allowing healthcare providers to obtain the efficiency benefits of CAC technology, while staying in full control of the coding process and without sacrificing quality. In particular, embodiments of the present invention may use a combination of automated (CAC) technology and human reviewers, structured and sequenced in a particular manner, to leverage the efficiency gains of CAC while using human reviewers to ensure accuracy.

Even more specifically, the use of the initial human reviewer **116** enables the system **100** and method **200** to catch certain errors in the CAC output **110**. Using a combination of the CAC module **108** and the initial human reviewer **116** may provide a higher quality output than that produced by the CAC module **108** alone, and at a lower cost

than using a highly-trained human reviewer alone, depending on the relative costs and accuracies of the CAC module **108** and the initial human reviewer **116**.

Furthermore, the initial human reviewer **116** may be relatively unskilled and be capable of correcting only relatively simple errors. Even so, the system **100** as a whole may be more efficient (measured, for example, in terms of accuracy per unit cost) and/or more accurate overall than the CAC module **108** itself, when the function performed by the final human reviewer **126** is taken into account. For example, if the final human reviewer **126** is an expert billing coder, then the final human reviewer **126** may catch and correct errors produced by the CAC module **108** that were not corrected by the initial human reviewer **116**, thereby increasing the accuracy of the final coding output **130**. Even if the cost of the final human reviewer **126** is relatively high (as measured, e.g., in terms of hourly wages), the overall cost of the system **100** may still be acceptable if the number of codes reviewed, and therefore the amount of time spent, by the final human reviewer **126** is relatively small. The system **100**'s use of the CAC module **108** and the initial human reviewer **116**, and in particular the system **100**'s use of the initial code assessment **114** and the modified code assessment **122**, enables the system **100** to limit the number of codes that the final human reviewer **126** must review, so that the cost of the final human reviewer **126** is kept low and so that the final human reviewer **126** is used to review and correct only relatively complex codes for which the expert skills of the final human reviewer **126** are required.

In addition to increasing the efficiency of the coding process, the system **100** and method **200** may increase the overall accuracy of the system **100** in comparison to a purely automated system (e.g., the CAC module **108**). As described above, the CAC module **108** may produce erroneous codes, especially in complex situations. The initial human reviewer **116** and the final human reviewer **126** may correct such codes. As a result, the system **100** may increase the accuracy of the final coding output **130** in comparison to the automatically-generated codes **112** produced by the CAC module **108**.

One benefit of the system **100**, therefore, is that it uses the CAC module **108** to produce the codes **112** automatically, and that it performs additional steps which increase the accuracy of the final coding output **130** in comparison to the codes **112** produced solely by the CAC module **108**. The system **100** may, therefore, be seen as an improved computer system for generating billing codes. The system **100**, therefore, solves the technical problem of how to increase the accuracy of the codes produced by a computer-automated coding module.

Furthermore, the system **100** and method **200** enable certain charts to be coded (at least in part) automatically, while also enabling codes to be generated based on charts containing clinical reports that cannot be processed automatically, such as clinical reports in the form of scanned handwritten notes. The system **100** and method **200** may code such clinical reports by routing those reports to the initial human reviewer **116**, who may generate an initial set of codes, and by then routing the initial set of codes to the final human reviewer **126** for review and correction. In this way, the system **100** and method **200** obtain the advantages of both the automated CAC module **108** and of the manual skill of the initial human reviewer **116** and the final human reviewer **126**.

As described above, one function performed by the chart routing module **150** is to determine whether the chart **106** is to determine whether the chart **106** qualifies for fully-automated processing by the CAC module **108**. Another, related, function performed by the chart routing module **150** is to determine the right time at which to submit the chart **106** to the CAC module **108** and/or to a human coder for coding. For example, the chart routing module **150** may be adapted not to submit the chart **106** (e.g., to the CAC module **108**) for coding unless and until a discharge summary has been received (e.g., unless and until the chart **106** includes a discharge summary). The chart routing module **150** may further be adapted to submit the chart **106** (e.g., to the CAC module **108**) after some predetermined maximum amount of time has passed, even if no discharge summary has been received (e.g., even if the chart **106** does not include a discharge summary). This is merely one example of a way in which the chart routing module **150** may determine the right time at which to submit the chart **106** for coding.

It is to be understood that although the invention has been described above in terms of particular embodiments, the foregoing embodiments are provided as illustrative only, and do not limit or define the scope of the invention. Various other embodiments, including but not limited to the following, are also within the scope of the claims. For example, elements and components described herein may be further divided into additional components or joined together to form fewer components for performing the same functions.

Any of the functions disclosed herein may be implemented using means for performing those functions. Such means include, but are not limited to, any of the components disclosed herein, such as the computer-related components described below.

The techniques described above may be implemented, for example, in hardware, one or more computer programs tangibly stored on one or more computer-readable media, firmware, or any combination thereof. The techniques described above may be implemented in one or more computer programs executing on (or executable by) a programmable computer including any combination of any number of the following: a processor, a storage medium readable and/or writable by the processor (including, for example, volatile and non-volatile memory and/or storage elements), an input device, and an output device. Program code may be applied to input entered using the input device to perform the functions described and to generate output using the output device.

Each computer program within the scope of the claims below may be implemented in any programming language, such as assembly language, machine language, a high-level procedural programming language, or an object-oriented programming language. The programming language may, for example, be a compiled or interpreted programming language.

Each such computer program may be implemented in a computer program product tangibly embodied in a machine-readable storage device for execution by a computer processor. Method steps of the invention may be performed by one or more computer processors executing a program tangibly embodied on a computer-readable medium to perform functions of the invention by operating on input and generating output. Suitable processors include, by way of example, both general and special purpose microprocessors. Generally, the processor receives (reads) instructions and data from a memory (such as a read-only memory and/or a random access memory) and writes (stores) instructions and data to the memory. Storage devices suitable for tangibly embodying computer program instructions and data include, for example, all forms of non-volatile memory, such as semiconductor memory devices, including EPROM,

EEPROM, and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROMs. Any of the foregoing may be supplemented by, or incorporated in, specially-designed ASICs (application-specific integrated circuits) or FPGAs (Field-Programmable Gate Arrays). A computer can generally also receive (read) programs and data from, and write (store) programs and data to, a non-transitory computer-readable storage medium such as an internal disk (not shown) or a removable disk. These elements will also be found in a conventional desktop or workstation computer as well as other computers suitable for executing computer programs implementing the methods described herein, which may be used in conjunction with any digital print engine or marking engine, display monitor, or other raster output device capable of producing color or gray scale pixels on paper, film, display screen, or other output medium.

Any data disclosed herein may be implemented, for example, in one or more data structures tangibly stored on a non-transitory computer-readable medium. Embodiments of the invention may store such data in such data structure(s) and read such data from such data structure(s).

What is claimed is:

1. A method performed by at least one computer processor executing computer program instructions stored on at least one non-transitory computer-readable medium, the method comprising:

(A) receiving, by a chart routing module executed by the at least one computer processor, data representing a medical chart;

(B) determining, by the chart routing module, whether the medical chart qualifies for automated processing by a computer-assisted coding (CAC) module, wherein determining whether the medical chart qualifies for the automated processing comprises:

determining whether the medical chart has a high confidence of being coded accurately by the CAC module, comprising determining whether the medical chart describes a complex medical procedure;

(C) in response to determining that the medical chart does not describe a complex medical procedure:

providing, by the chart routing module, the medical chart to the CAC module;

performing CAC, by the CAC module, on the medical chart to produce an initial set of billing codes automatically;

receiving, by the chart routing module, the initial set of billing codes from the CAC module;

determining, by the chart routing module, whether a skill value associated with an initial reviewer exceeds a particular value;

providing, by the chart routing module, the initial set of billing codes to the initial reviewer in response that the skill value associated with the initial reviewer exceeds the particular value;

receiving, by the chart routing module, from the initial reviewer, a modified set of billing codes and modified code assessment data that represents an assessment of accuracy and completeness of the modified set of billing codes; and

providing, by a coding output routing module executed by the at least one computer processor, a final coding output for a final review, wherein the final coding output comprises the medical chart, the modified code assessment data, and the modified set of billing codes, and wherein providing the final coding output for the final review results in correctness of errors in the modified set of billing codes received from the initial reviewer and increase in efficiency of a coding process, which lead to increase in accuracy of the final coding output and reduction in costs associated with the coding process; and

(D) in response to determining that the medical chart describes a complex medical procedure:

providing the medical chart to the initial reviewer;

receiving the initial set of billing codes from the initial reviewer; and

providing the initial set of billing codes for the final review, wherein providing the initial set of billing codes for the final review results in correctness of errors in the initial set of billing codes.

2. The method of claim **1**, wherein the data representing the medical chart includes data representing a freeform text document.

3. The method of claim **1**, wherein the data representing the medical chart includes data representing a structured document.

4. The method of claim **3**, wherein the data representing the structured document comprises data representing an XML document.

5. The method of claim **1**, wherein the data representing the medical chart comprises data representing a data record in a database.

6. The method of claim **1**, wherein the data representing the medical chart includes data representing at least two of: a freeform text document, an XML document, and a data record in a database.

7. A system comprising at least one non-transitory computer-readable medium storing computer program instructions executable by at least one computer processor to perform a method, the method comprising:

(A) receiving, by a chart routing module executed by the at least one computer processor, data representing a medical chart, wherein the chart routing module is configured to perform one or more routing determinations on the data;

(B) determining, by the chart routing module, whether the medical chart qualifies for automated processing by a computer-assisted coding (CAC) module, wherein determining whether the medical chart qualifies for the automated processing comprises one of:

determining whether the medical chart comprises scanned handwritten notes; and

determining whether the medical chart has a high confidence of being coded accurately by the CAC module;

(C) in response to determining that the medical chart qualifies for the automated processing by the CAC module:

providing, by the chart routing module, the medical chart to the CAC module;

performing CAC, by the CAC module, on the medical chart to produce an initial set of billing codes automatically;

receiving, by the chart routing module, the initial set of billing codes from the CAC module;

determining, by the chart routing module, whether a skill value associated with an initial reviewer exceeds a particular value;

providing, by the chart routing module, the initial set of billing codes to the initial reviewer in response to determining that the skill value associated with the initial reviewer exceeds the particular value;

receiving, by the chart routing module, from the initial reviewer, a modified set of billing codes and modified code assessment data that represents an assessment of accuracy and completeness of the modified set of billing codes; and

providing, by a coding output routing module executed by the at least one computer processor, a final coding output for a final review, wherein the final coding output comprises the medical chart, the modified code assessment data, and the modified set of billing codes, and wherein providing the final coding output for the final review results in correctness of errors in the modified set of billing codes received from the initial reviewer and increase in efficiency of a coding process, which lead to increase in accuracy of the final coding output and reduction in costs associated with the coding process; and

(D) in response to determining that the medical chart describes a complex medical procedure:

providing the medical chart to the initial reviewer;

receiving the initial set of billing codes from the initial reviewer; and

providing the initial set of billing codes for the final review, wherein providing the initial set of billing codes for the final review results in correctness of errors in the initial set of billing codes.

8. The system of claim **7**, wherein the data representing the medical chart includes data representing a freeform text document.

9. The system of claim **7**, wherein the data representing the medical chart includes data representing a structured document.

10. The system of claim **9**, wherein the data representing the structured document comprises data representing an XML document.

11. The system of claim **7**, wherein the data representing the medical chart comprises data representing a data record in a database.

12. The system of claim **7**, wherein the data representing the medical chart includes data representing at least two of: a freeform text document, an XML document, and a data record in a database.

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